Status and Trends for Selected Diving Duck Species Examined by the Marine Bird Component, Puget Sound Ambient Monitoring Program (PSAMP), Washington Department of Fish and Wildlife

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Introduction

The Wildlife Management Program of the Washington Department of Fish and Wildlife (WDFW) was given responsibility in 1991 to design and implement monitoring plans for marine birds, waterfowl, and marine mammals under the Puget Sound Ambient Monitoring Program (Monitoring Management Committee 1988). The bird and mammal portions of the Puget Sound Ambient Monitoring Program (PSAMP) were not funded until the 1991–93 biennium. Study design for the bird portion of the task, along with consolidation of historical databases, was contracted November 20, 1991 to Ecological Consulting Inc. (ECI). Some of the present project staff began in mid-May 1992 under the Game Division of the Wildlife Management Program to direct, conduct, and coordinate this task. The final implementation plan was produced in March 1993 (Nysewander et al. 1993), even though surveys and contract field work were begun during the summer of 1992 and the winter of 1992–93.

Objectives

The Monitoring Management Committee set down the following goals for monitoring of bird resources under PSAMP in 1988:

- To monitor the abundance of selected avian species to identify any significant changes or trends that may be related to pollution, habitat loss, or disturbance; and
- To monitor reproductive success and contaminant levels in birds.

The first goal was addressed by WDFW and resulted in the development of objectives to document through aerial surveys the habitat use, densities, and trends seen over time throughout all of greater Puget Sound for selected key species for two annual periods: summer and winter. Certain species were selected for emphasis in monitoring by the project's implementation plan (Nysewander et al. 1993) using criteria related to usage of or dependence upon marine waters of Puget Sound, to peaks of abundance during our survey windows, and to other concerns due to limited numbers or special vulnerability to humanly caused mortality.

Methods

The surveys primarily utilized a Dehaviland Beaver float plane. The plane flew at 80–90 knots (kt) at an altitude of approximately 65 meters (m) above sea level. The use of an on-board computer linked to a global positioning unit (GPS) provided a record of time and position every 5 to 10 seconds during the survey. Two observers recorded all birds seen along a 50 m wide strip on each side, along with observation times to the nearest 5 seconds. A third person ran the computer, monitored the GPS unit and output, and directed the pilot to different census routes. This track line was then interpolated by computer with the sightings, using the time of the sightings relative to the time and position fixes generated by the GPS. The sampling protocols and methodology, described in greater detail in the marine bird and mammal implementation plan (Nysewander et al. 1993), follow the general methods developed over the last two decades in California and the Pacific Northwest (Briggs et al. 1981, 1987, 1991).

The aerial surveys were stratified by effort into two levels: higher densities found near shorelines and lower densities found offshore or in open waters. Almost all of the nearshore habitat (<ca. 20 m or 10 fa) was sampled by transects that followed the shoreline in a roughly parallel pattern whereas the offshore habitat (>ca. 20 m) was sampled in a zigzag pattern. A turning angle of 90 degrees was initially used on the zigzag pattern. To reduce variance on estimates of bird concentrations found in certain deeper waters, sharper turn angles were subsequently used after the first year, thereby increasing the percentage of offshore area sampled. The flights were extended after the first year to include the Washington state side of the western half of the Strait of Juan de Fuca. After the first year, the nearshore habitat was surveyed in two different ways: 1) the parallel fashion described above for nearshore habitat that was relatively narrow; and 2) a more intensive zigzag or S pattern where the nearshore habitat stretched extensively offshore such as at a river mouth or estuary.

The PSAMP aerial surveys recorded all bird species seen from the high tide line down, but data analyses for monitoring purposes have concentrated on the following set of species: pigeon guillemot (*Cepphus columba*), common murre (*Uria aalge*), rhinoceros auklet (*Cerorhinca monocerata*), marbled murrelet (*Brachyramphus marmoratus*), western grebe (*Aechmophorus occidentalis*), bufflehead (*Bucephala albeola*), two species of goldeneye (*Bucephala islandica and B. clangula*), three species of scoters (*Melanitta perspicillata, M. fusca, and M. nigra*), greater and lesser scaup (*Aythya marila and A. affinis*), and harlequin duck (*Histrionicus histrionicus*). This paper will focus primarily on most of the diving duck species just listed.

The survey data has been incorporated into both computer databases and GIS mapping programs in both the PC and Unix formats. This data is available through standard map products for all species by counts, densities, distribution and habitat use, or indices of population estimates with associated confidence limits. A synthesized historical database of comparable data from studies as far back as 1978 was created through contract. Comparisons of our present work with this historical database has allowed status and trends to begin being evaluated, especially for selected marine species that are restricted to marine waters. Indices of abundance and distribution have been most useful in the summer for diving birds associated with gill net mortality studies and in winter for diving ducks in long-term waterfowl inventories.

Results for Diving Bird Species

Abundance, Distribution, Habitat Use, and Densities

Puget Sound contains more than 3,200 kilometers (km) of marine shoreline. The PSAMP aerial surveys flew between 3,070 and 3,432 km of transects along nearshore habitat and between 1,846 and 3,458 km of transects through the offshore habitat during each summer or winter aerial survey period (Figure 1). The actual proportion of each total habitat area in inner marine waters of Washington sampled ranged per each survey period from 13% to 15% for the nearshore and 3% to 5% for the offshore habitat component.

The winter pattern of overall bird distribution observed by PSAMP surveys differed, both in numbers as well as geographically, from that of summer. These changes included the following:

- A three-fold increase in bird numbers from (63,187–105,094) in summer to (131,674–273,712) in winter.
- A larger number of birds used the southern Puget Sound during winter than summer.
- During winter, waterfowl usage increased along shorelines and river deltas, with certain estuaries, including the Skagit River delta and Padilla Bay, containing large numbers of waterfowl and geese.
- During winter, grebes and loons migrated into the Sound and used protected waters (deeper waters with relatively low currents) in all of greater Puget Sound excluding the Strait of Juan De Fuca, and portions of the San Juan Islands.

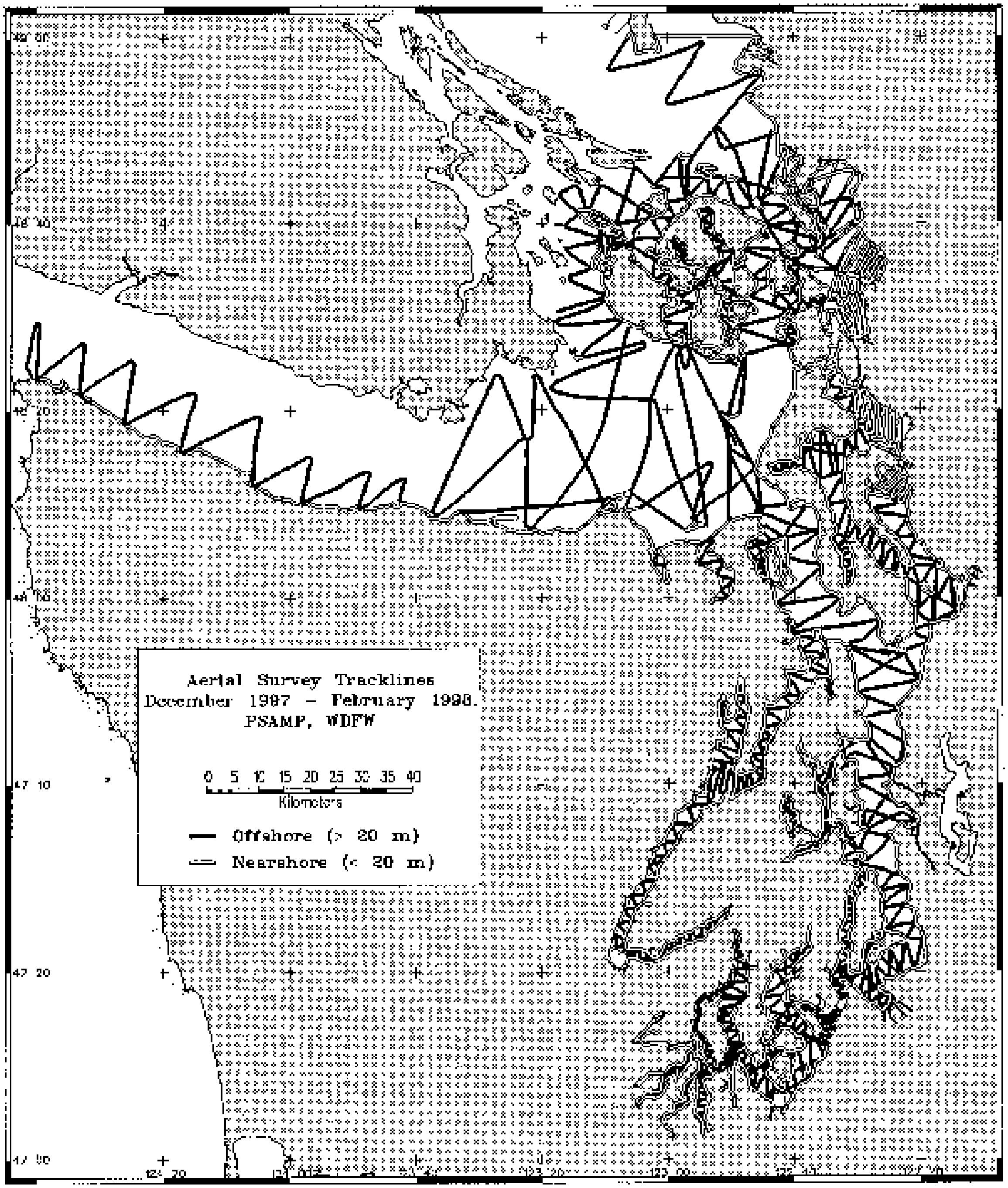

Figure 1. Representative coverage as illustrated by 1997–98 winter aerial survey track lines.

Waterfowl comprised 61–67% of all birds counted during 1994–98 winter surveys ($\bar{x}$ =64.21, s.d.=4.65). Sea and bay ducks comprised 26–41% of the waterfowl ($\bar{x}$ =34.0, s.d.=4.72) depending upon the influx of dabbling duck species into the marine habitat. The diving duck numbers were more consistent from year to year since they did not have the flexibility of utilizing other habitats not surveyed by PSAMP that dabbling duck species could. Actual on-transect counts of diving ducks ranged from 52,794 to 98,411 in 1994–98, with scoter, bufflehead, and goldeneye species being the most numerous. Scoters made up 33–41% ($\bar{x}$ =36.65, s.d.=2.6), bufflehead comprised 23–24% ($\bar{x}$ =23.08, s.d.=0.63), goldeneyes comprised 15–18% ($\bar{x}$ =16.54, s.d.=0.93), and scaup comprised 6–10% ($\bar{x}$ =7.3, s.d.=2.06) of the diving ducks counted in the 1994–98 winter periods (Figures 2 and 3).

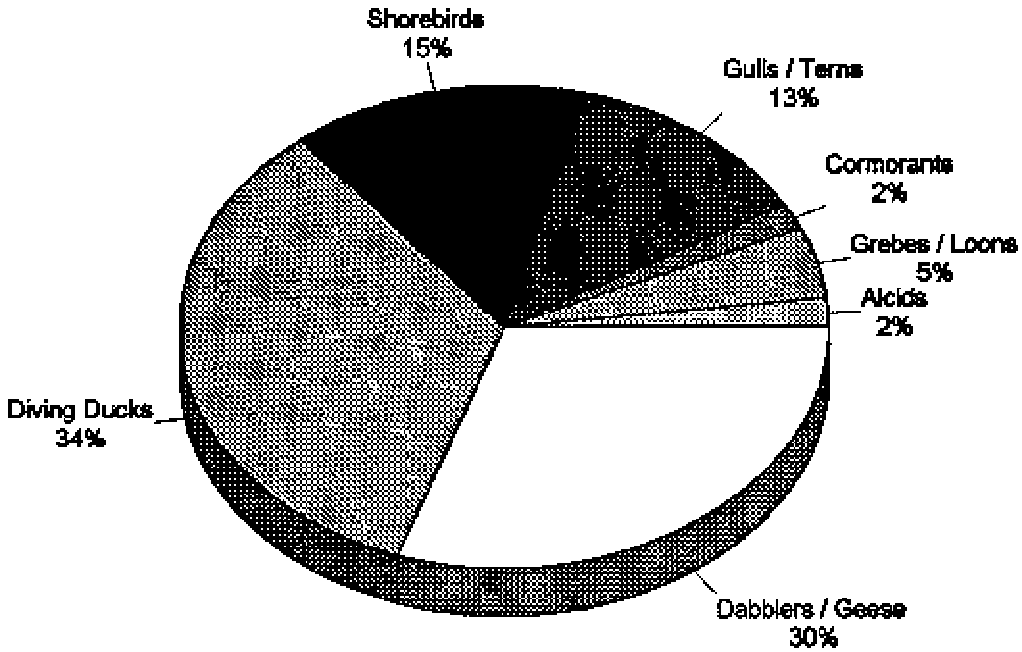

Figure 2. Composition of marine bird populations in greater Puget Sound from PSAMP winter aerial surveys, 1994–98.

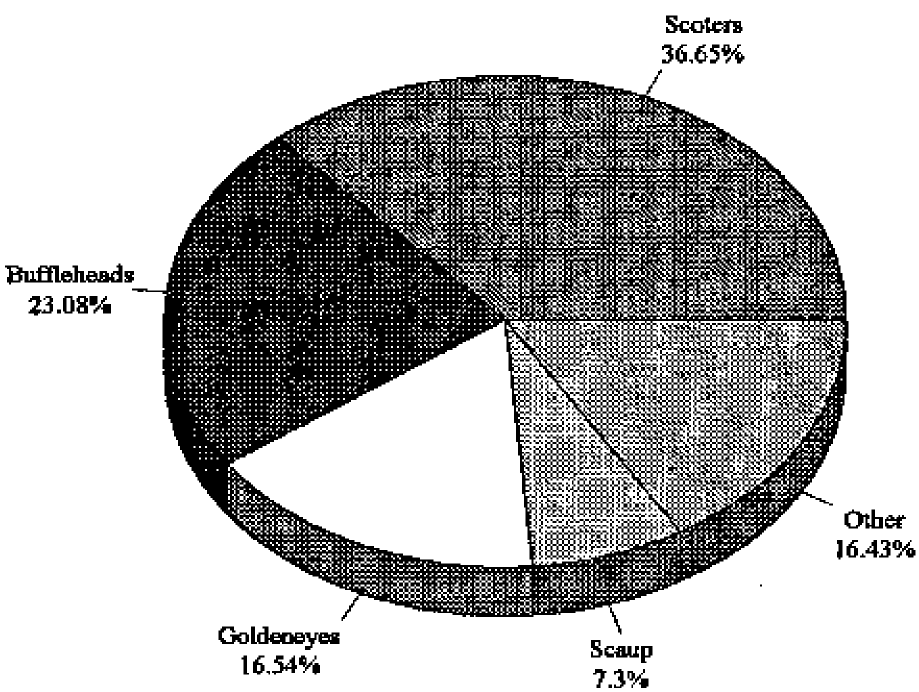

Figure 3. Species composition of sea and bay ducks in greater Puget Sound from PSAMP winter aerial surveys, 1994–98.

Of all the scoters counted on-transect from 1993–98 winter periods, 33–54% were identified to species. Of these, surf scoters comprised 55–80% ($\bar{x}$ =41.22, s.d.=6.91), white-winged scoters comprised 18–40% ($\bar{x}$ =28.29, s.d.=9.17), and black scoters made up 3–9% ($\bar{x}$ =4.67, s.d.=2.06).

Nearly all of the scaup counted in PSAMP winter surveys are likely to be greater scaup. Scoter and scaup distribution for Puget Sound recorded in the 1993–98 winter surveys are displayed by densities that result from the counts when combined with survey effort (Figures 4 and 5).

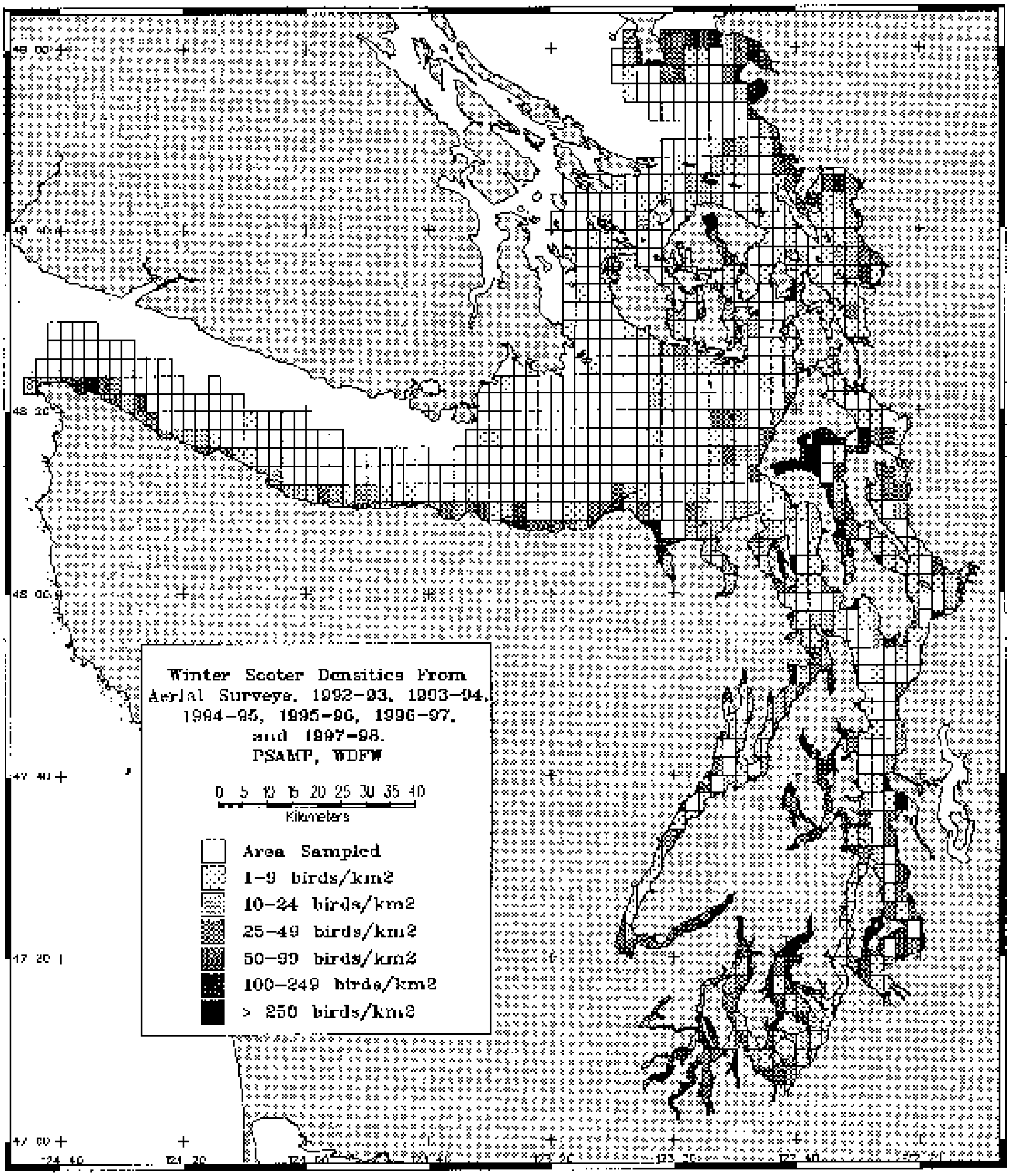

Figure 4. Scoter densities observed winters 1993–98 on PSAMP aerial surveys.

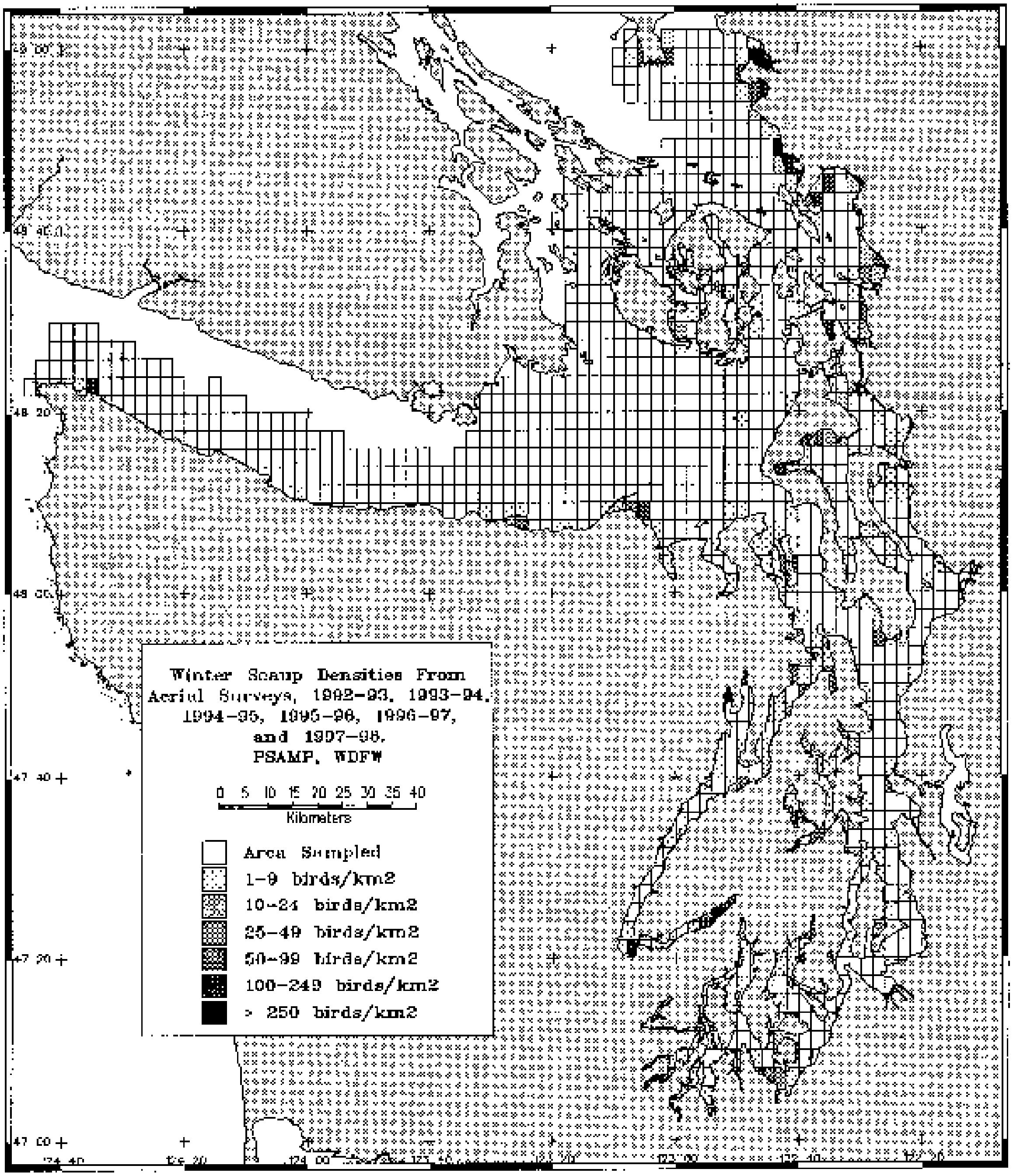

Figure 5. Scaup densities observed winters 1993–98 on PSAMP aerial surveys.

Trends Throughout the Pacific Flyway

Recent reports on status of sea and diving ducks have suggested that certain species have declined (Goudie et al. 1994; Henny et al. 1995; Trost 1998) in certain portions of the Pacific Flyway. We examined what data is available for other portions of the Pacific flyway for the following four diving duck species and compared this with the data now available for greater Puget Sound.

Greater Puget Sound

Comparisons of indices derived from the recent PSAMP surveys and the 1978–79 MESA studies (Wahl et al. 1981) support other Pacific flyway data that suggest wintering scoters and scaup have declined in numbers over the last 15 to 30 years in western Washington and throughout the flyway (Figures 6 and 7). Goldeneyes and buffleheads, using a similar nearshore habitat, do not show this same pattern in marine waters of western Washington (Figure 8). The decline of scaup is probably associated in part with a different wintering pattern on the west coast than that associated with the scoter species; this will be discussed in more detail in the section of this report centering on wintering scoters and scaup in San Francisco Bay.

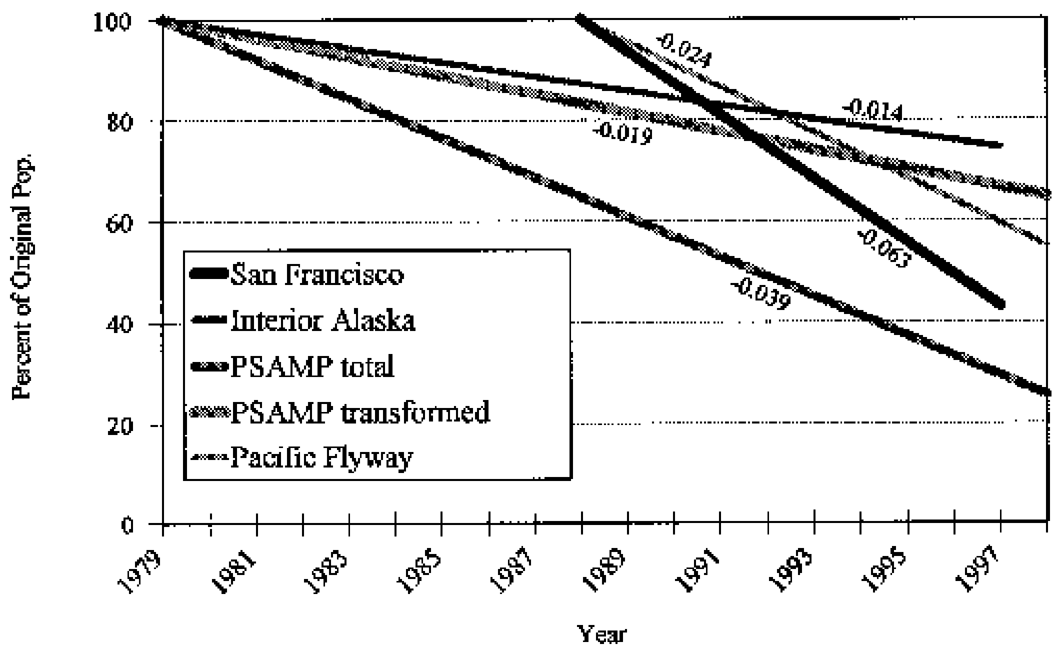

Figure 6. Trends in scoter populations in Alaska, Washington, and San Francisco Bay.

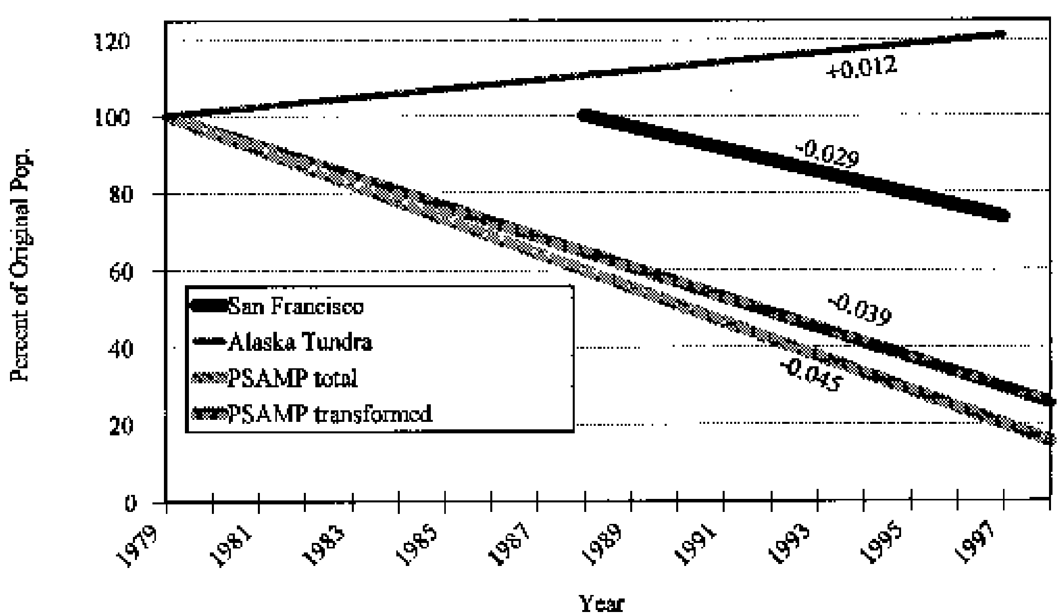

Figure 7. Trends in scaup populations in Alaska, Washington, and San Francisco Bay.

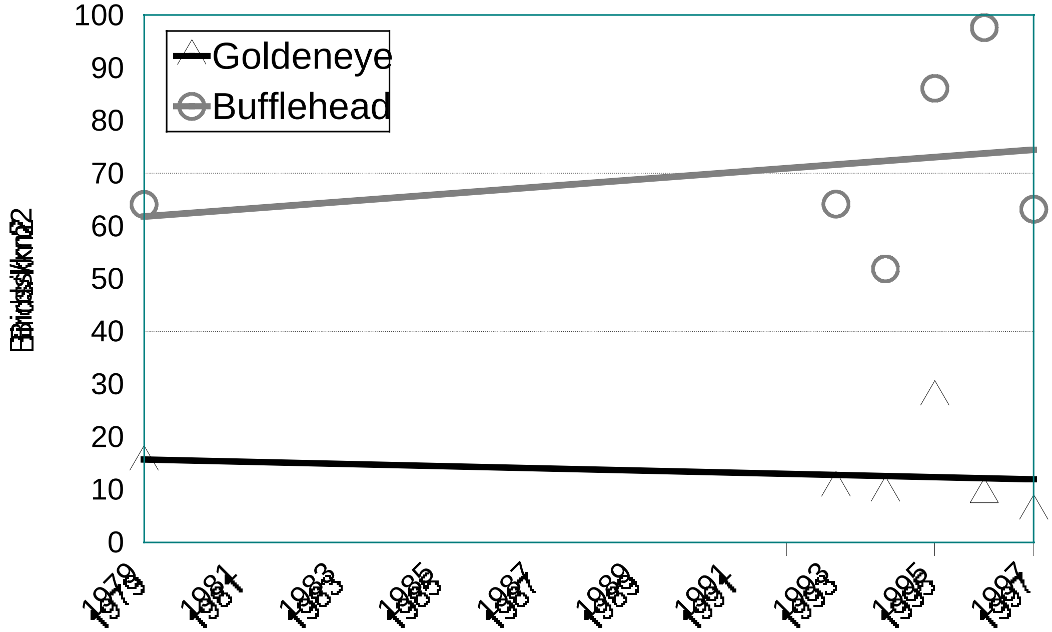

Figure 8. Densities of goldeneye and bufflehead between MESA (1978–79) and PSAMP (1993–98) for shared transects.

The initial design contract for the PSAMP surveys in Washington state also produced a digital database of the historical data available, primarily data associated with the MESA studies in 1978–79. This contract also provided software to develop indices with confidence limits. When this was utilized on both the recent PSAMP 1993–98 surveys and the MESA 1978–79 surveys, the results appeared to indicate that the decline might be in the range of 50–70% (Figure 9). This scoter decline should be used with caution, however, for when we examined the historical database and software developed to calculate population indices, two sources of error were discovered. The software was treating different survey methodologies equally in the comparison and calculations of population indices. The 1978–79 MESA surveys utilized three to four types of survey methods: surveys from either small boats or ferries, aerial surveys, and point counts from shore. The aerial survey method was the least emphasized of these, especially in near-shore areas. The aerial method was employed mostly in areas where access by land was limited, and in the open water regions where access by boat was more difficult. The 1992–98 PSAMP surveys only utilized the aerial method. It was also discovered that the software was not treating the data appropriately and is in need of corrections in the code.

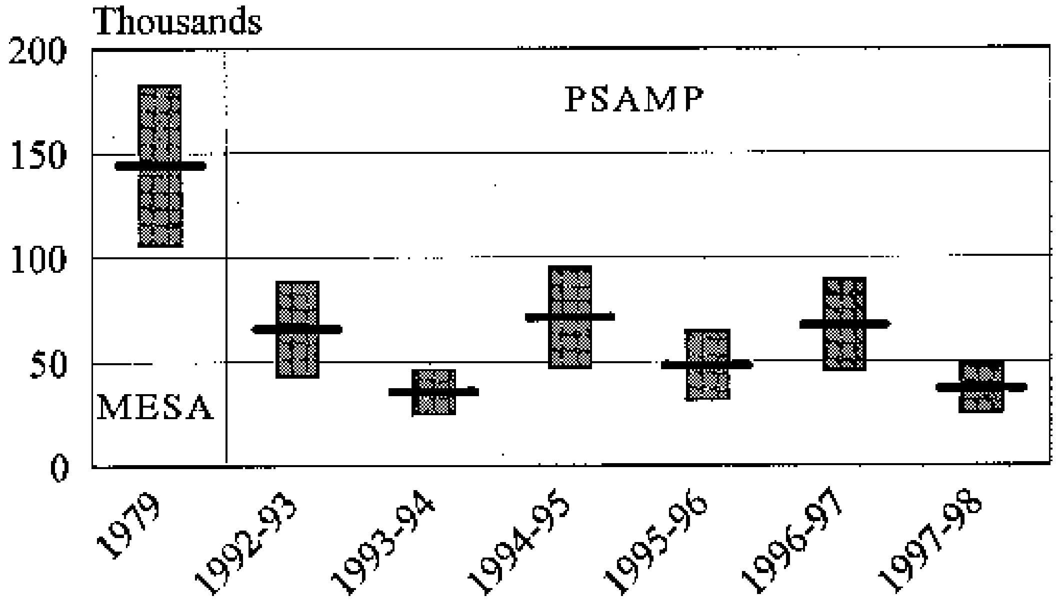

Figure 9. Comparison of winter scoter population indices (with 95% C.L.) in MESA areas using PSPOP Software, for MESA (1978–79) and PSAMP (1993–98) periods.

To come up with a more comparable way to assess changes in densities between the 1978–79 MESA surveys and the PSAMP surveys, those near-shore aerial transects flown in the MESA surveys that were comparable to the PSAMP transects were selected. Similar transects were found in 19 MESA sub-regions, comprising 65.56 km^2 surveyed during MESA transects, and 303.27 km^2 surveyed during PSAMP transects (Figure 10). Two methods were used to calculate densities for scoters and scaup from these data.

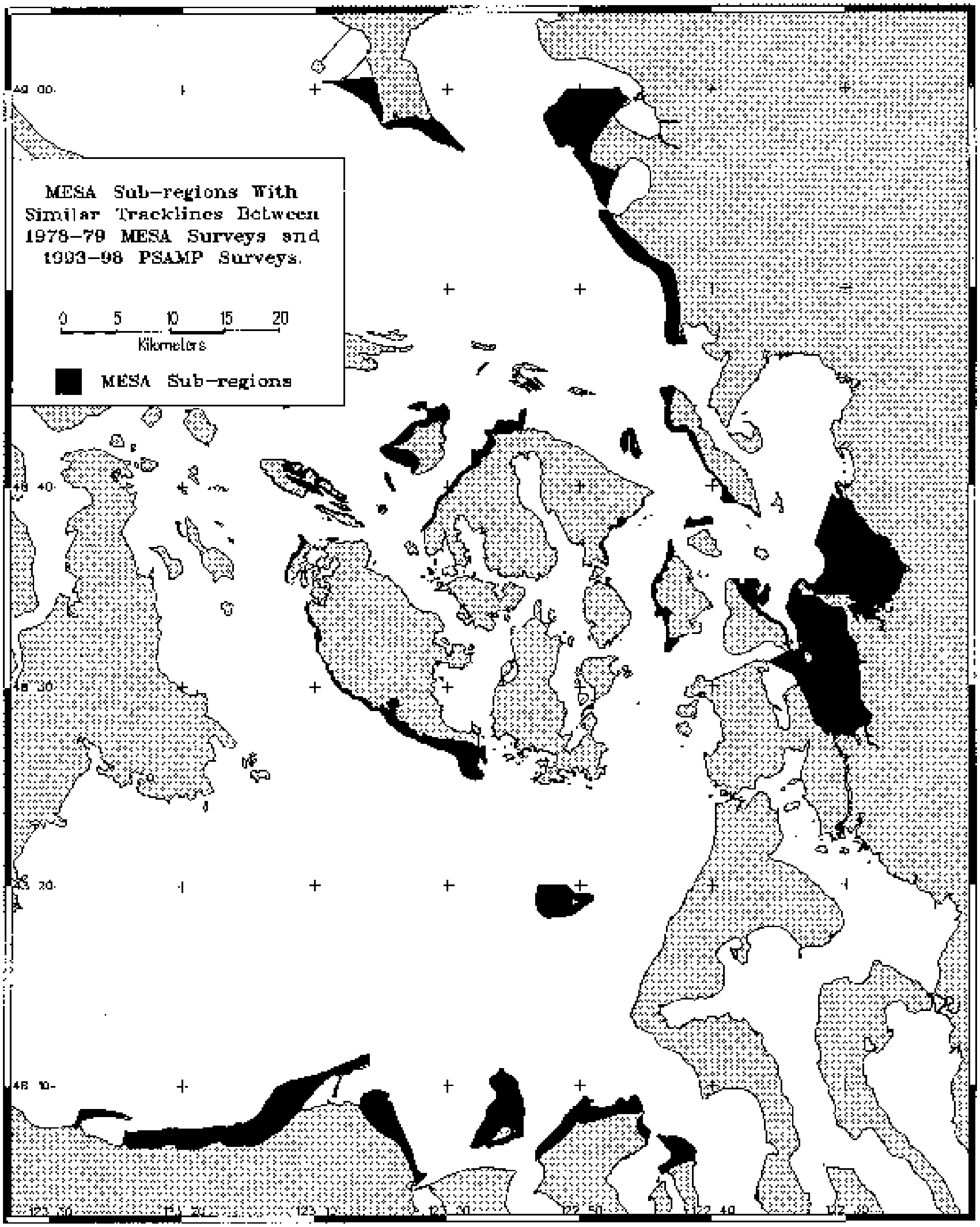

Figure 10. Areas with similar aerial transects flown in MESA and PSAMP time periods.

The first method calculated an overall density for each winter period (1978–79 MESA, and all six winter PSAMP surveys) from the total number of scoters and scaup divided by the total area covered by the transects the respective season. This method suggested a decline in scoter and scaup densities of 65.7% and 70.4%, respectively, over the 18-year period (Figure 11).

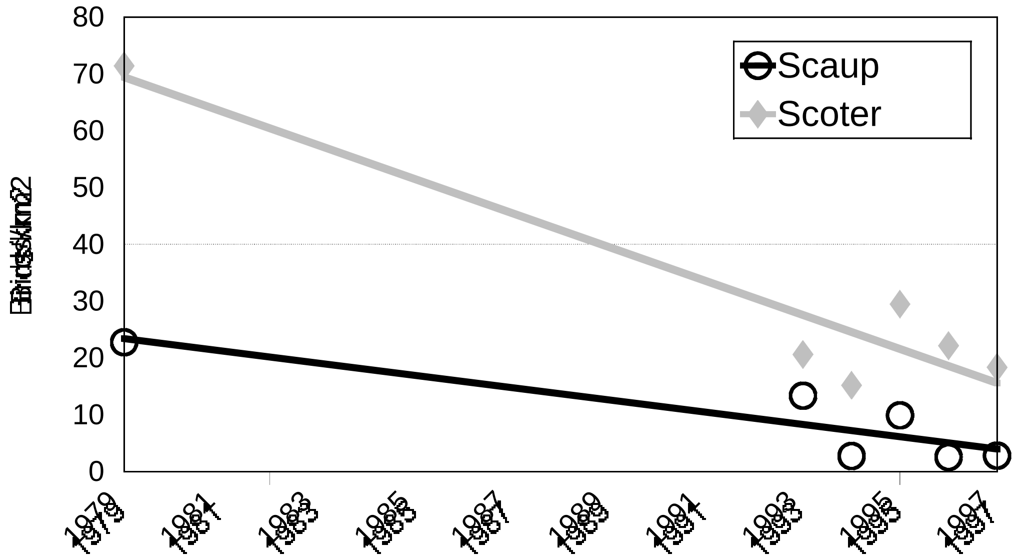

Figure 11. Decline of overall total densities of scoters and scaup on shared transects compared between MESA (1978–79) and PSAMP (1993–98) in greater Puget Sound.

The second method was used to determine estimated means of, and confidence limits for, scoter and scaup densities within the 19 MESA sub-regions. The data was combined into two periods: 1978–79 MESA transects (N=118 sample units) and 1993–98 PSAMP transects (N = 211 sample units). Densities for each sample unit were log-transformed. An estimated mean density, for each period, was calculated weighting by sample unit area, and then back-transforming the value of the mean logged density. Difference between the periods was tested by factorial ANOVA. This method presented a significant decrease in both scoter densities (P=0.024, 35.32% decline between periods), as well as scaup densities (P=0.000, 74.56% decline between periods). The slopes for annual change from the earliest estimated index is -0.019 for scoters and -0.039 for scaup using the transformed densities from the comparable transects (Figures 12 and 13; also Figures 6 and 7).

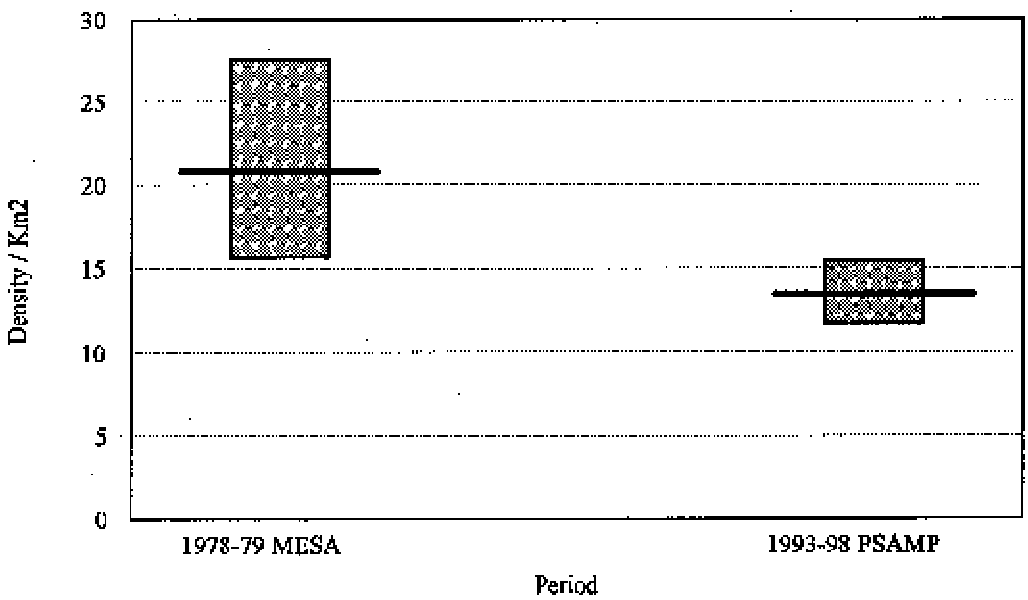

Figure 12. Comparison of estimated mean densities (with 90% confidence limits) of scoters for shared transects between MESA (1978–79) and PSAMP (1993–98).

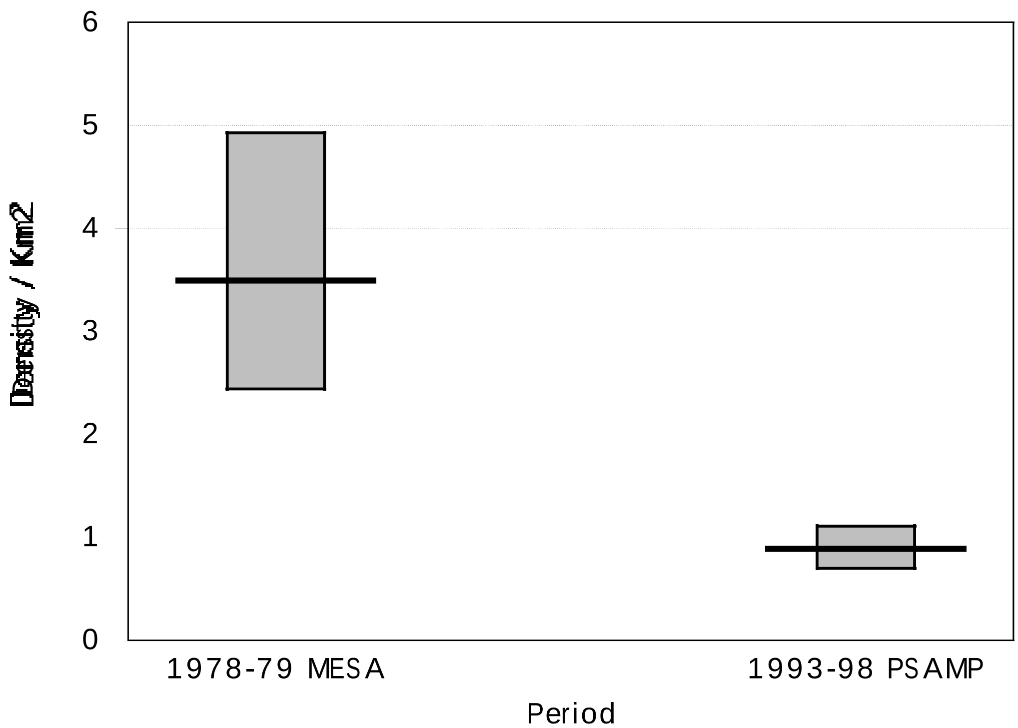

Figure 13. Comparison of estimated mean densities (with 90% confidence limits) of scaup for shared transects between MESA (1978–79) and PSAMP (1993–98).

In an effort to evaluate whether portions of the wintering scoter population may have moved from one portion of Puget Sound to another, we also compared the indices and confidence limits by MESA area versus the southern portions of Puget Sound for all years of the PSAMP surveys where all areas were covered by the survey (Figure 14). We utilized the indices calculated by the original contracted software, because we have not had a chance to redo these. Currently we are making the assumption that the relative changes would not be changed by new programs, but this analysis will be revisited when a new program is developed. At the present, it appears that any decrease or increase any one year in the MESA (northern) study area seems reflected by a similar change in the southern portion of Puget Sound. This suggests that local movement may not be a major factor in these declines.

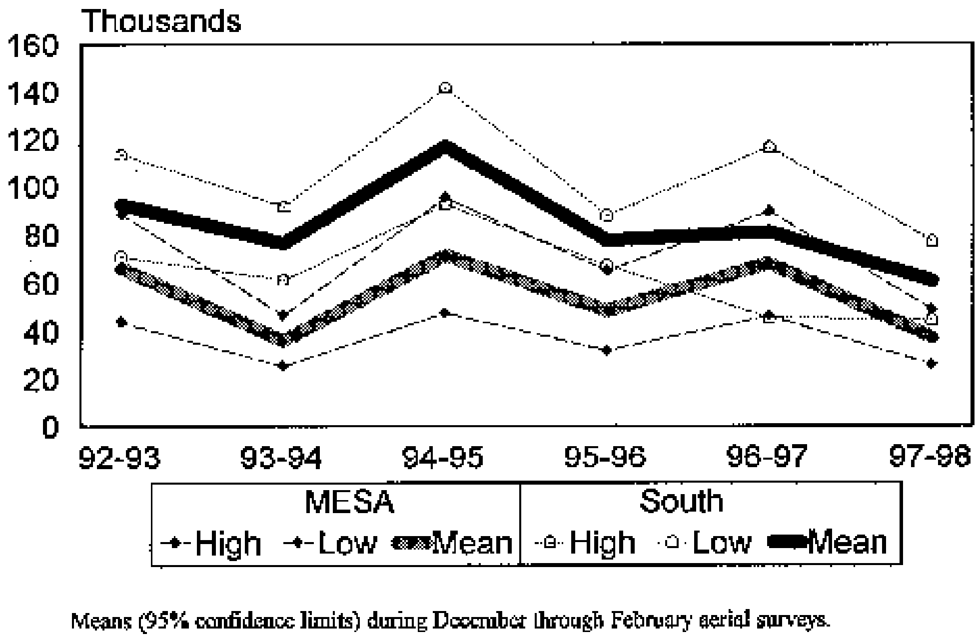

Figure 14. Comparison of scoter indices in winter during PSAMP surveys between northern (MESA study area) and southern greater Puget Sound.

San Francisco Bay

Scoter and scaup species are also important components of wintering diving ducks associated with San Francisco Bay. More intensive type surveys have looked at the open bays and salt ponds of San Francisco Bay between 1988 and 1997. The overall estimates that have been derived from this work are part of the midwinter waterfowl counts and were provided by Dr. John Takekawa, USGS, Biological Resources Division (Figure 15). Two caveats should be mentioned about this data: surf scoters make up 99% of scoters seen here, and both greater and lesser scaup are found here, although the greater scaup should still be more predominant in the marine settings. These data are either overall counts or estimates and are not displayed as means. Hence, for comparison sake, the degree of change displayed here may be most comparable to overall counts, indices, or densities for Puget Sound rather than the mean densities derived earlier.

Much higher numbers of scaup (by an order of magnitude) utilize San Francisco Bay than are found utilizing greater Puget Sound. Nevertheless, both scoters and scaup appear to be declining over the last ten years. We do not know if this same trend occurred during the previous decade, but the slope of annual change from the earliest estimated index (1988) is -0.026 for scaup and -0.057 for scoters over the last ten years (Figures 6 and 7).

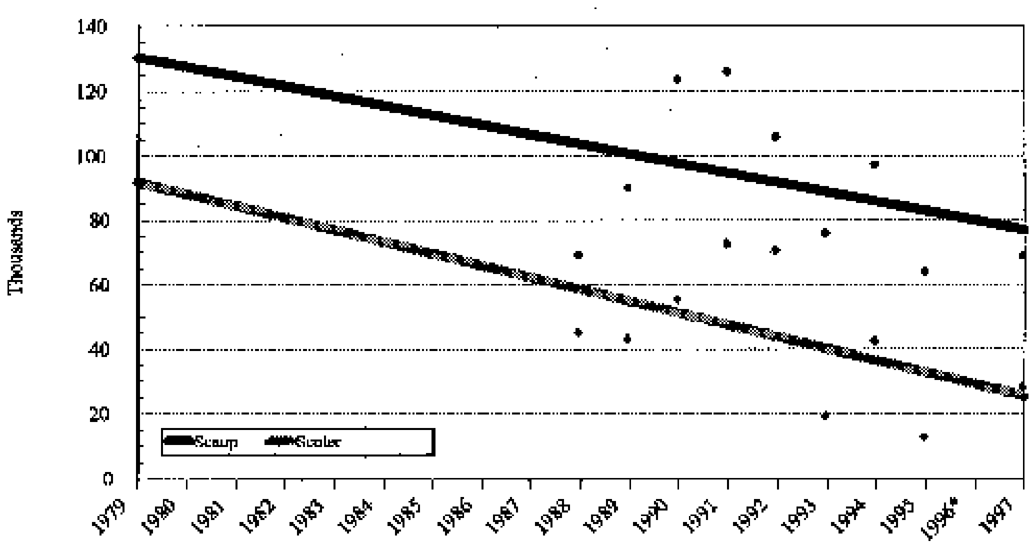

Figure 15. Scoter and scaup numbers in San Francisco Bay midwinter censuses 1988–1997 (Takekawa pers. comm. 1998). Note: open bays and salt ponds were not surveyed in 1996.

Lower Columbia River

The lower Columbia River and estuary are somewhat different from San Francisco Bay and greater Puget Sound in that the waters are more influenced by fresh water and river dynamics than by marine conditions. Hence this estuary appears to be more attractive to scaup than to scoter,s and it may include larger percentages of lesser scaup which may be undergoing different dynamics than the greater scaup population. The estuary is also much smaller in size. There is less of a consistent survey approach that is comparable to that conducted in recent years in both San Francisco Bay and greater Puget Sound (i.e., the PSAMP protocols and aerial surveys). At the present time we were only able to look at data for 1993–98 that was relatively consistent in its survey scope.

Scoters are consistently present only in low numbers (<1000) as are most other marine diving duck species like bufflehead and goldeneyes (Figure 16). The lower Columbia River may be used during migration by scoters for short periods as they move up the coast, but it does not serve as a wintering ground for large concentrations of and hence gives us no added perspective on changes over time. Scaup use of the lower Columbia differs from that of scoters, with numbers usually in the 5,000 to 13,000 range with one peak reaching almost 21,000 in 1996, equal to or greater than that observed recently in greater Puget Sound during any annual PSAMP survey. However, as most of the scaup observed in the lower Columbia were present in the most upstream portion of the estuary, it is unclear which species (lesser or greater scaup) comprise these numbers since this is probably the more fresh water portion of this estuary which lesser scaup prefer. At any rate, the declines in both greater Puget Sound and San Francisco Bay overwhelm any temporary increase seen one year in the lower Columbia River.

Other Wintering Areas

Significant numbers of scoters winter (in differing species compositions) in British Columbia, southeast Alaska, and other portions of Alaska (i.e., Kodiak Island). Some estimates of populations have been made, but trend data is not available as yet for these areas to the best of our knowledge. Conant et al. (1988) estimated through aerial surveys and correction factors that 51,256 scoters (±69%), but only 283 scaup (±156%), probably winter in the northern half of southeast Alaska. Aerial surveys in British Columbia (Vermeer et al. 1983) counted 33,477 scoters January–February on 7,138 km of transects throughout much of the marine coastal habitat; they estimate that half the birds present were observed (Savard 1982). Forsell and Gould (1980) estimated that 35,000 white-winged scoters, 5,000 surf scoters, and 3,750 scaup wintered in the Kodiak Island area. It is uncertain from available data whether decreases in some areas might have been balanced out by changes in these other wintering areas, but the 1997–98 fall and winter waterfowl survey report for the Pacific flyway (Trost 1998) lists overall numbers for scoters on wintering areas 1988–98 that suggest declines are occurring throughout the flyway (Figure 17).

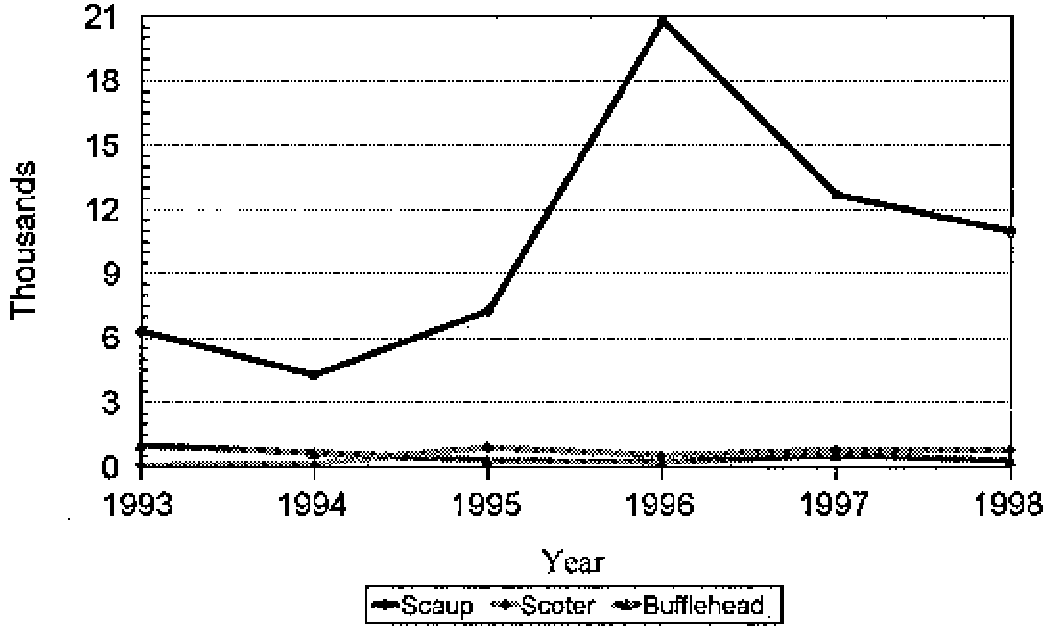

Figure 16. Scaup, scoter, and bufflehead numbers in lower Columbia River estuary midwinter censuses 1993–98 (Kraege unpub. data).

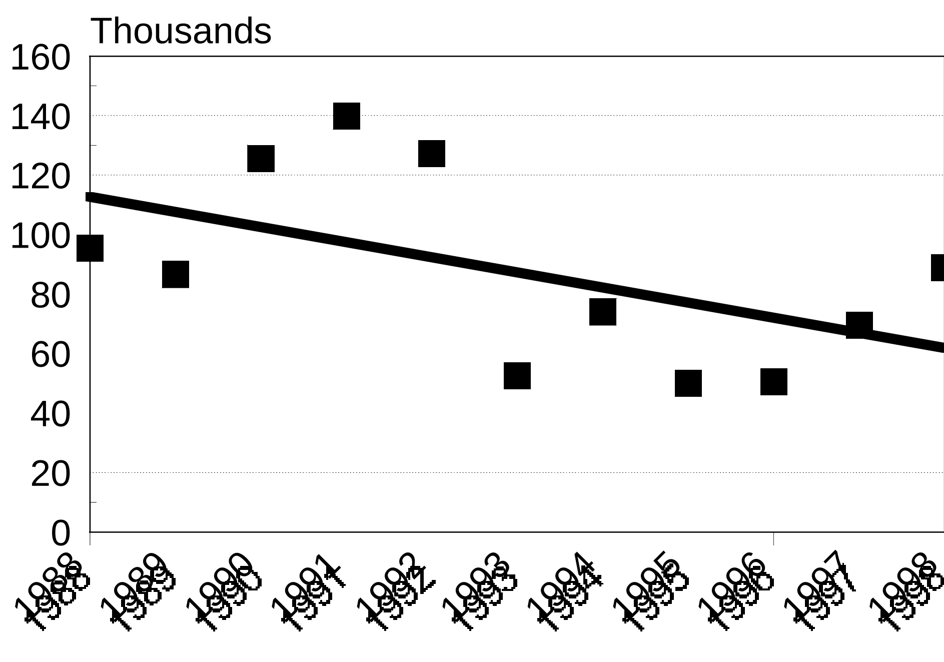

Figure 17. Trends in scoters from midwinter censuses in Pacific Flyway 1988–98 (Trost, R.E. 1998).

Alaska Breeding Estimates

Major breeding concentrations of ducks in Alaska have been consistently monitored each summer since 1957 with strip transect sampling from aircraft (Hodges et al. 1996). Starting in 1977, these surveys switched to a different type of aircraft, and since then the surveys have followed the same protocol. Scoter observations include all three species and scaup sightings combine two species whenever they were encountered. However, the Alaskan surveys can be separated by areas. Interior or taiga portions would include only surf and white-winged scoters whereas the coastal or tundra areas include all three species of scoters. Conversely, the tundra or coastal scaup are primarily the greater scaup. Little is known about what interchange may occur between years between areas. Surf scoters may or may not move between the coastal and interior portions of Alaska any one year. We are making the assumption that it is more comparable to choose an area that has no black scoters to compare with what is seen in western Washington marine waters, where black scoters are not abundant.

Hodges et al. (1996) suggested that the populations of diving ducks (*Aythya* spp.) and sea ducks (*Bucephala* spp. and *Melanitta* spp.), except those of mergansers (*Mergus* spp.) and canvasback (*Aythya valisineria*), declined by 15–75% during 1976–94. Data recently obtained that includes the last three years (Hodges, pers. comm.) portrays a recent upswing in both scoters and scaup in portions of their breeding range, thereby reducing or eliminating some of the decline documented earlier. In spite of this, scoters continued to decline in interior Alaska by 23.8% over 18 years, a slope from original estimate of -0.013 (Figures 6 and 18), while the tundra scaup increased by 10.4% over 18 years, a slope of +0.006 (Figure 7 and 19). In the case of scaup in Alaska, the total numbers estimated greatly exceed any total found in greater Puget Sound and San Francisco Bay combined. This finding suggests that the Alaska population either 1) contributes to several different American or Asiatic flyway populations, 2) experiences considerable mortality before they arrive in wintering grounds, or 3) the breeding surveys in Alaska included populations moving through to eastern Siberia or other portions of their breeding range. Scaup populations in North America have declined since the mid-1980s, and do not appear to be responding to current improvements in water conditions on the breeding grounds (Allen and Caithamer 1998). Hence, the larger numbers estimated in Alaska stand in contrast to some of the evidence gathered elsewhere in North America.

Conclusions and Concerns

Pacific Flyway

- Significant declines are being recorded in portions of the Pacific flyway for at least two species groups of diving ducks commonly found in greater Puget Sound: scoters and scaup.
- The rate of decline in the wintering areas of Puget Sound and San Francisco Bay for both scoters and scaup are equal to or greater than those recorded in the Alaska breeding grounds.

Greater Puget Sound

- The wintering populations of scoters have declined significantly since 1978. The exact rate of decline can be debated, but by all estimates or indices the declines are accumulating to sizable proportions as the decline continues over an ever-increasing period of years.
- Bufflehead and goldeneyes have not exhibited this same pattern of decrease in wintering populations using greater Puget Sound, but have demonstrated either a stable or slightly increasing trend.

Dramatic declines in numbers of scoters and associated stocks of herring spawners have demonstrated many similarities in timing and scale (Figure 20). Scoters have historically moved in late winter and early spring to concentrate in large numbers near forage fish spawning occurrences like Cherry Point (Wahl et al. 1981), and would feed on the concentrations of roe just before migrating north to breeding grounds. This phenomena in March and April has not been monitored in recent years. It seems probable that this spring concentration of scoters would show at least similar declines to those documented for scoters in wintering areas like greater Puget Sound.

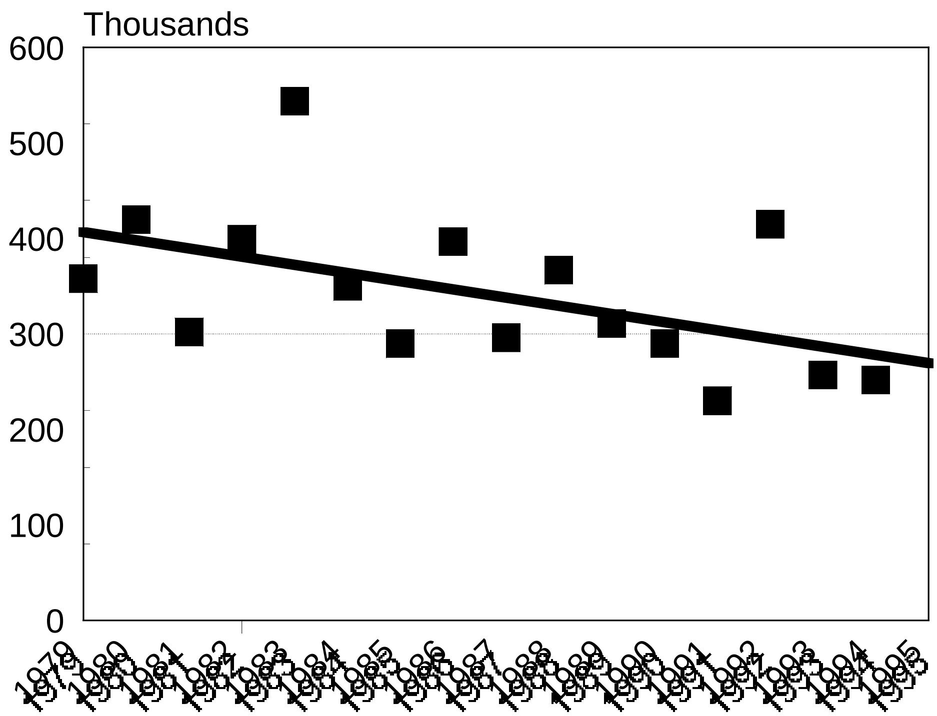

Figure 18. Trends in scoters estimates in interior Alaska observed by summer aerial surveys 1979–97 (Hodges et al. 1996). Note: By choosing only interior Alaska scoter surveys, the focus is on the same two primary scoter species found in Washington.

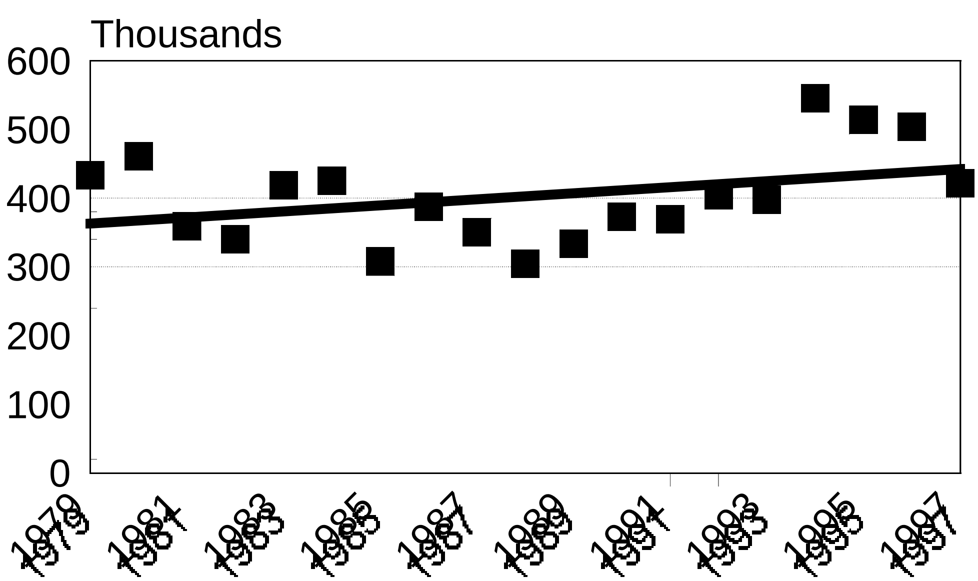

Figure 19. Trends in tundra scaup estimates in Alaska seen on summer aerial surveys 1979–97 (Hodges pers. comm. 1998).

- Scoters and scaup differ in their distribution and habitat use in Puget Sound. Scoters are often seen where scaup are located, but scaup are not always located where there are scoters. This may be due in part to the fact that scoters are more numerous than scaup, but it may also reflect a different use of marine habitats in Puget Sound. The PSAMP surveys observed goldeneyes and buffleheads pursuing different patterns of habitat usage than those observed for either scoters or scaup. These differences were similar to those documented earlier in Puget Sound for wintering sea ducks (Hirsch 1980). In Hirsch's study, different sea duck species overlapped in their usage of the nearshore marine habitats, but the different species varied from each other in terms of food types sought, foraging style utilized, and portion of the nearshore habitat searched for food items.

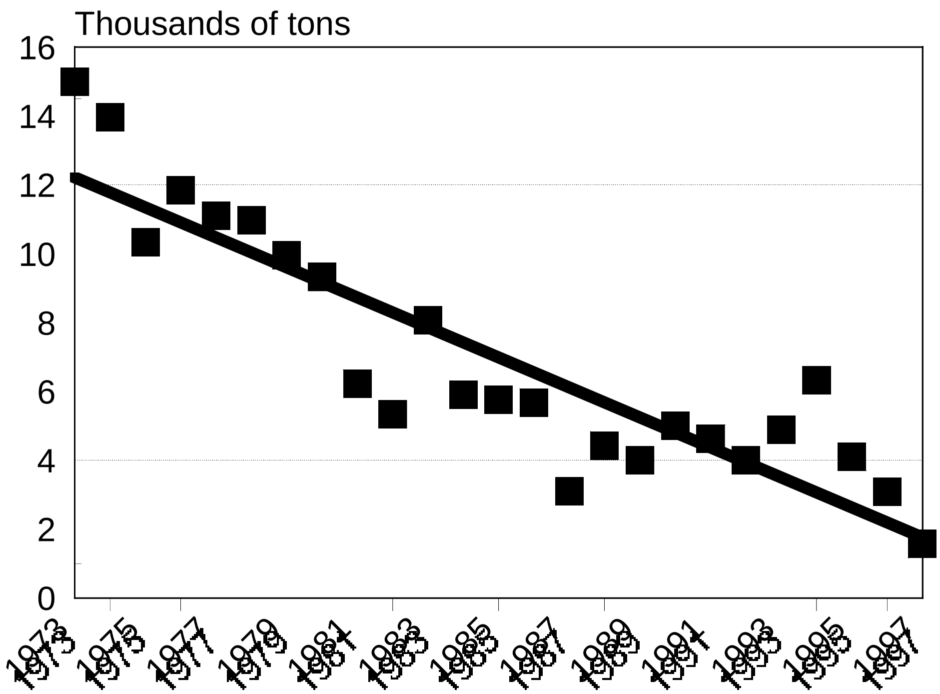

Figure 20. Trends in herring spawning estimates at Cherry Point, Washington 1979–97.

Implications of this Work

This component's efforts have concentrated on monitoring numbers and distribution of marine birds, their patterns of habitat usage, and trends in these factors over time. None of the decreases evaluated in this paper would have been perceived without a commitment to a long term series of standardized monitoring. The longest survey effort (Alaska breeding grounds) has been the most effective in documenting both greater and lesser degrees of change. It is important to keep monitoring efforts continuing at both wintering and breeding grounds if we are to be able to recognize and evaluate trends over time, but research concerning causes might consider some of the following topics for hypotheses to examine.

Contaminants

Scoters have been known to accumulate contaminants during their stay at wintering grounds (Henny et al. 1991). Two recent studies concerning surf or white-winged scoters in the Pacific flyway (Henny et al. 1995 and Mahaffy et al. 1997) did not clearly implicate nor eliminate contaminants in terms of some role that they may play in the mortality and decreases of scoters recorded recently. However, the sample size is very small and little is known about the levels of contaminants required to cause deleterious effects in these diving duck species.

Breeding Ground Factors

Failures at the breeding grounds have been documented preliminarily for scoters (Henny et al. 1995), but causes have not been determined. Harvest by hunting does occur both in the spring and fall in or near the breeding areas in Alaska. Documentation of this is incomplete, but subsistence harvest in Alaska was estimated in 1996 to include 17,593 scoters (Paige and Wolfe 1997). It is unclear whether this is considered normal or exceptional. Much of the harvest is by natives and has been under-reported in the past.

Migration Stressors

Unusual mortality was documented during August 1990, 1991, and 1992 for molting adult scoters in southeast Alaska (Henny et al. 1995). Population stability of sea ducks is dependent on high adult survival and a few successful years of reproduction (Goudie et al. 1994). The mortality in southeast Alaska is not compatible with this reproductive strategy, and suggests something is stressing populations of scoters frequenting the Pacific flyway.

Wintering Conditions

The decrease in scoter numbers in the wintering areas appears to be equal to or greater than those recorded for the breeding areas. This suggests that wintering factors might be at least part of the causes behind declines. Since there is no demonstrated movement between areas of greater Puget Sound and other wintering areas of the Pacific flyway that would account for the decreases, the following would be potential categories to examine concerning changes on the wintering grounds:

- Habitat changes;
- Food web changes; or
- Effects from any one or combination of the three climate changes or cycles that influence the Pacific flyway (El Niño, North Pacific Decadal Oscillation, and the 1979 climate shift in North Pacific).

Implications for Other Species and Management

- Scoters are considered environmental indicators that can help in evaluating the health of Puget Sound because of their widespread occurrence and their consumption of several different components of the food chain: shellfish and eggs of forage fish at spawning concentrations of forage fish like herring.
- Other species of concern, like harlequin ducks, depend upon roe from the forage fish spawning concentrations that occur during spring in British Columbia and Washington (i.e., Denman and Hornby Islands in the Strait of Georgia). If changes in spawning forage fish stocks turn out to be key factors in scoter declines, it would appear likely that these reductions of forage fish may well tie in with other declines for other species.
- The Strait of Georgia and the northern half of the greater Puget Sound make up the same ecosystem and can not be managed or understood well without integrated monitoring, research, and analysis.
- The same food chains that support these migratory bird populations also sustain both anadromous and non-anadromous fish as well as marine mammal and bird populations. This correspondence must be addressed via some unified approach, which should include the management of commercial and subsistence harvest by humans.

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